REMARKS

Claims 1-11 and 13-22 are pending in the present application. All of the claims 1-11 and 13-22 stand rejected as unpatentable under 35 USC §103:

a) Claims 1-5, 7-11, 13-17 and 19-22 stand rejected as obvious over Maddess *et al.* U.S. Publication No. 2003/0163060 in view of Livingstone *et al.* U.S. Patent No. 5,474,081.

b) Claims 6 and 18 stand rejected as obvious over Maddess *et al.* in view of Livingstone *et al.* and further in view of Thornton U.S. Patent No. 6,743,183.

Applicant respectfully traverses these rejections for the reasons detailed below.

Prior Art References

No combination of the references teaches or suggests the present invention.

Maddess *et al.*

Maddess *et al.* describes ensembles of multiple independent stimuli that are presented to subjects. The independence of the stimuli in the ensemble derives from pseudorandom temporal sequences that determine the appearance or non-appearance of each of the stimuli in the ensemble. Thus, for an ensemble of N stimuli, there are N different temporal modulation sequences. This arrangement permits responses to each of the N stimuli to be measured.

Maddess *et al.* teaches interleaving aperiodic null stimuli, and using mean presentation rates between 0.25 and 25 presentations per second, and more

particularly 1 and 6 presentations per second, so that signal-to-noise ratios are enhanced compared to not inserting such breaks. Such stimuli are said to be *temporally sparse*. These mean presentation rates derive from the random appearance rates of the stimuli and do not imply a periodic rate determined by a fixed interval.

Livingston *et al.*

Livingston *et al.* describes a method for presenting one stimulus at a time, recording the response, and then presenting another stimulus from a predefined series of stimuli. Given that only one stimulus is presented at a time, Livingston *et al.* does not, and cannot, teach anything about how an ensemble of independent stimuli should be presented in order to improve signal-to-noise ratios. Furthermore, Livingston *et al.* teaches that the optimal stimuli should be continuously presented throughout the measurement period, with only the contrast of the single stimuli altered. Also, those stimuli are preferably periodic. Since no breaks are presented in the stimulus sequence (*i.e.*, no null stimuli are inserted), the stimuli cannot be either temporally or spatially sparse. In this sense, Livingston et al teaches that non-sparse stimuli are optimal, that is, the opposite of the claimed invention.

Figs. 2 and 3 of Livingston *et al.* are depictions of single grating and checkerboard stimuli and bear no relationship to Figs. 3 and 10 to 13 of the present application. That is, Figs 2 and 3 of Livingston *et al.* show single stimuli in which all the component parts are modulated by one periodic sequence, generating one response at one frequency.

Livingston *et al.* teaches that the optimal stimuli are neither temporally nor spatially sparse, but are what are known as steady state (SS) stimuli. Such stimuli are well known and are defined in standards for testing human subjects with pattern Electroretinograms (ERGs) or pattern Visual Evoked Potentials (VEPs) published by the International Society for Clinical Electrophysiology in Vision (ISCEV, www.iscev.org/standards). The stimuli are referred to as steady state, because the stimuli are on continuously although attributes such as the contrast of the stimulus may be modulated periodically. There are no-null stimuli interleaved and so by definition SS stimuli cannot be sparse. Livingston *et al.* also teaches that these SS stimuli should stimulate the magnocellular visual pathway.

Livingston *et al.* also repeatedly teaches that only one stimulus at a time should be tested, and describes in detail what these single visual stimuli should look like (*e.g.*, Figures 2 and 3 of Livingston *et al.*). In marked contrast, the invention recited in independent claim 1 defines optimally the spatial and temporal layout for the case when an ensemble of several independent stimuli are presented at the same time (*i.e.*, concurrently). Clearly, a method as described by Livingston *et al.* that only teaches a method for single stimuli teaches nothing about how multiple stimuli should be presented, as required by the claimed invention.

For example, beginning at column 2, line 26, Livingston *et al.* states:

> In general, the present invention presents to a subject eye **a series of patterns** of **spatially varying light intensity**. Each pattern provides a degree of contrast between areas of varying light intensity, and different patterns have different degrees of contrast between respective areas of varying light intensity. **For each pattern as presented, the present invention measures response of the eye.**

Thus, one stimulus at a time is presented serially (*i.e.*, one after the other), and the response to each is measured during presentation of each single stimulus. *See* col. 2, lines 41-42:

> In a preferred embodiment, **the series of patterns** that are presented to the subject eye are checkerboard patterns.

The presentation of single stimuli in Livingston *et al.* is obvious from the "pseudo-code" program for generating the single stimuli described in col. 6, lines 1-30 and col. 7, lines 24-44. The program clearly shows the method for drawing a single checkerboard stimulus. That single stimulus is then modulated in time (by the routine "flicker()"), the response is recorded and then a new pattern in the sequence is drawn, modulated and the response recorded, until the complete series of stimuli of choice has been displayed. *See* col. 7, lines 24-26:

> In the preferred embodiment, the level or degree of contrast changes between each checkerboard pattern in the series of patterns displayed in the apparatus 21 of FIG. 1a.

A clear demonstration of the intent to present and measure responses to one stimulus at a time is given at col. 7, line 34, col. 7, line 37, and col. 7, line 41:

> ... **one checkerboard pattern in the series** of displayed patterns comprises ...
>
> and
>
> A second or **succeeding checkerboard pattern in the series** ...
>
> and
>
> **A following** or third checkerboard pattern **in the series** has ...

That paragraph explains that the successively presented single stimuli can be of various luminance contrasts. These singly presented stimuli are then said to contain a certain number of checks of a certain size (see col. 7, lines 58-62). The Office Action states that these lines describe a spatially sparse ensemble of stimuli when in fact the passage describes a single stimulus.

In short, Livingston *et al.* teaches a method for presenting a series of stimuli and recording responses to each, one at a time, and neither teaches nor suggests anything about how a set of concurrently presented independent stimuli should be arranged in time and space, in accordance with the claimed invention.

Thornton

Thornton describes a method of simultaneously stimulating an auditory system. Figs. 22A and 22B of Thornton show the stimuli to be periodic at different rates, the rates being defined but the fixed interval between the stimuli being as described in the Abstract and the passage at col. 2, line 11 of Thornton:

> … stimulating the sensory system with a first stimulus train having stimuli temporally separated from each other by a first inter-stimulus interval and simultaneously stimulating the sensory system with a second stimulus train having stimuli temporally separated from each other by a second inter-stimulus interval different from the first inter-stimulus interval.
>
> and
>
> … stimulating the auditory system with at least two pulse trains having slightly different pulse repetition frequencies …

The method of Thornton involves means for selecting particular temporal windows for sampling the evoked response (*e.g.*, see col. 5). These windows have nothing to do with the stimuli and are only a means for processing the response. Thus, Thornton teaches the use of *periodic stimuli that are on continuously*. As such the stimuli also contain no intervals of null stimuli. The stimuli are not therefore temporally sparse.

The two sound sources of Thornton could be positioned at different spatial points in front of the listener, or along some other spatial dimension. However, Thornton does not teach anything about any spatial arrangement. Also, given that there are no null-stimuli, and only stimuli that are continuously on, there is no possibility of the stimuli being spatially sparse. The periodically presented stimuli can be of different types, differing in qualities such as pitch or bandwidth (*see* col. 7, lines 34-40), but again nothing is said about or suggests modulating the stimuli along these dimensions such that the stimuli would be sparse (*i.e.*, containing long aperiodic null stimuli) along those stimulus dimensions. Accordingly, Thornton neither teaches nor suggests anything about temporally or spatially sparse stimuli. Instead, Thornton teaches the opposite, which is that the optimal stimuli are continuously on with no breaks (null-stimuli).

Claims

The claims clearly distinguish from any proper combination of the references.

Independent Claims 1 and 11

The claimed invention differs from Maddess *et al.* by using ensembles of stimuli with identical temporal sparseness. Claim 1, for example, recites, *inter alia*, "varying using a processor each sequence over time between a null stimulus and one or more less frequent non-null stimuli", and claim 11 similarly recites "a processor adapted to vary each sequence" in the same manner.

Such ensembles of stimuli can differ in the SNRs produced in response to each stimulus, depending on the degree of spatial sparseness across the ensemble. Claim 1 recites "simultaneously presenting two or more parts of the sensory system with respective sequences of spatially sparse stimuli", and controlling "the variation of each sequence so that neighbouring parts of the sensory system are less likely to receive simultaneous non-null stimuli", and claim 11 recites a stimulator and processor which function in the same manner. A *spatially sparse* stimulus ensemble is one where few to no stimuli in the ensemble are co-presented with their spatial neighbors.

Thus, the claimed invention clearly involves an operation and apparatus providing a benefit not anticipated, taught or suggested by Maddess *et al.*

That is, the invention defined by claims 1 and 11 provides the surprising advantage that two different arrays of currently presented stimuli, *that were identically temporally sparse,* could produce very different signal-to-noise ratios depending on their *spatial sparseness*. Spatial sparseness refers to a given stimulus not having any near neighbors in the spatial (*i.e.*, non-temporal) dimensions of the stimulus ensemble. Thus, in terms of the appearance of the stimuli on at any time step, the stimuli are still

temporally sparse but on every time step any presented stimulus will preferentially not be near any other (see paragraphs [0015], [0036], [0077], [0099], and [0091] of the present application). Importantly, the stimuli do not appear at random locations but are spatially constrained, unlike Maddess *et al.* The claimed invention extends the definition of spatial sparseness to all non-temporal dimensions of the concurrently presented array, such as tactile or audio dimensions. Importantly, the multiple independent stimuli present along dimensions such as tactile or visual space are presented concurrently.

The effect of spatial sparseness is best demonstrated by Fig. 8 of the present application and the text associated with it (see paragraph [0104] of the present application). As explained at paragraph [0104], ten subjects were tested with three stimulus types, each of which was identically temporally sparse. That is, valid stimuli were transient presented between longer periods when no valid stimulus was shown at the same mean rates. One of the stimulus arrays is a reference stimulus like those used to generate Fig. 7 of the present application, where the locations at which stimuli occur on any time step are random and so not infrequently stimuli will appear neighboring each other as in Fig. 4 and paragraph [0051] of the present application. The two types of spatially sparse stimuli are illustrated in Figure 3 of the present application and a means for generating spatially sparse stimuli is given in the flow chart of Fig. 5 (paragraph [0052]), and in the text of paragraph [0064].

For Type I, the possible stimulus locations are divided into two families A and B. A and B form a regular tessellation of test locations (*i.e.*, not random locations). As shown in Fig. 5 and stated in paragraph [0064] of the present application, on a time step any of the members of family A have a low probability of showing a stimulus otherwise they are neutral grey (no stimulus), and the members of family B have 0 chance of showing a stimulus. This means any member of A that does show a stimulus is guaranteed to be surrounded by many regions B that show no stimulus, hence the stimulus is spatially sparse. On the next frame, family B may show a stimulus but not A. Again, the presented array of stimuli on this step is spatially sparse. This process of switching between families A and B is repeated. The mean rate of delivery of stimuli and no stimuli (*i.e.*, the temporal sparseness), is arranged to be identical to the reference stimuli.

The second type of stimulus, Type II, simply divides the possible stimulus locations into 4 families, A to D, and at any time step only regions drawn from one family are possibly showing a stimulus, while the other three families show no stimulus. Thus, no stimulus ever has any neighbors that are also showing a stimulus. As shown in Fig. 8, the spatial sparse stimuli showed significantly increased signal-to-noise ratios even though their temporal sparseness is identical to the reference stimulus.

Spatial sparseness has a separate and potentially beneficial effect to temporal sparseness. Maddess *et al.* does not disclose or even suggest this aspect of the claimed invention.

In contrast to Livingston *et al.*, the claimed invention teaches stimuli that are both temporally and spatially sparse to improve signal-to-noise ratios even more than stimuli that are simply temporally sparse. Figs. 3 and 10 to 13 of the present application show ensembles of many independent stimuli, each of which is modulated by a separate sequence and each of which therefore generates its own response (*e.g.*, Figure 6 of the present application). In conjunction with a method as in Fig. 5 of the present application, Figs. 3 and 10 to 13 of the present application illustrate how to manipulate the stimulus sequences of the ensemble to produce a spatially sparse ensemble of stimuli, as claimed in claim 1. Livingston *et al.* does not disclose or teach this.

Thus, it is submitted that Maddess *et al.* alone, Livingston *et al.* alone, or the two in combination do not disclose or suggest the claimed invention. Furthermore, Thornton alone or in combination with the other references does not disclose or suggest the claimed invention. It is therefore respectfully submitted that independent method claim 1 is in condition for allowance. As independent apparatus claim 11 tracks directly on independent claim 1, it is submitted that independent claim 11 is similarly in condition for allowance.

<u>Claims 2-10 and 13-22</u>

In paragraphs 2-4 of the Office Action, the dependent claims are rejected as being unpatentable over Maddess *et al.* in view of Livingstone *et al.*, or over Maddess *et al.* in view of Livingstone *et al.* and further in view of Thornton.

Since independent claims 1 and 11 are in condition for allowance as set forth above, it is submitted that respective dependent claims 2-10 and 13-22 are similarly each in condition for allowance.

For the above stated reasons, all of pending claims 1-11 and 13-22 are submitted to be allowable. Early notification to that effect is respectfully requested.

Respectfully submitted,

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